UNITED STATES PATENT APPLICATION

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FOR

MULTI-DOMAIN LIQUID CRYSTAL DISPLAY DEVICE

This application claims the benefit of Korean Patent Application No. 2000-1403, filed on

January 12, 2000, which is hereby incorporated by reference for all purposes as if fully set

forth herein.

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a liquid crystal display device, and more

particularly, to a multi-domain liquid crystal display device in which a common auxiliary

electrode is formed around and in a pixel region on the same layer as a gate line, and an

electric field induction window and a dielectric structure are formed in the pixel region.

Discussion of the Related Art

Among flat-panel displays enjoying image quality equivalent of the one

offered by cathode ray tubes (CRT), liquid crystal displays (LCD) have been most widely

adopted. In particular, a thin-film transistor (TFT) type LCD (TFT-LCD) has been used in

personal computers, word processors, office automation equipment, and home electrical

appliances including, among other items, a portable television sets. The market for suck

LCDs is expected to further expand in the future. Accordingly, there is a demand for further

improvement in image quality.

A description will be made by taking the TFT LCD for instance. However, the

present invention is not limited to the TFT LCD but can apply to a simple matrix LCD, a

plasma addressing type LCD and so forth. Generally, the present invention is applicable to

LCDs which include liquid crystal sandwiched between a pair of substrates on which

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electrodes are respectively formed and displays images by applying voltage between the electrodes.

Currently, a mode most widely adopted for the TFT LCD is a normally-white mode that is implemented in a twisted nematic (TN) LCD. The technology of manufacturing the TN TFT LCD has advanced considerably in recent years. Contrast and color reproducibility provided by the TN TFT LCD have surpassed those offered by the CRT. However, the TN LCD has a critical drawback of a narrow viewing angle range, which limits the application of the TN LCD.

Figs. 1A to 1C are diagrams for explaining the narrow viewing angle problem. Fig. 1A shows a state of white display to which no voltage is applied and liquid crystal molecules are aligned in the same direction with a slight inclination (about 1° to 5°). For convenience sake, the liquid crystal molecules are illustrated as in Fig. 1A. In this state, light is seen nearly white in any azimuth. Moreover, as shown in Fig. 1C when voltage is applied, intermediate liquid crystal molecules, except those located near the alignment films, are aligned in a vertical direction. Incident linearly-polarized light is therefore seen black, but not twisted. At this time, the direction of light obliquely incident to a screen (panel) is twisted to some extent because it passes obliquely through the liquid crystal molecules that are aligned in the vertical direction. The light is therefore seen halftone (gray), but not perfect black.

As shown in Fig.1B, when an intermediate voltage, which is lower than the voltage applied in the state shown in Fig.1C, is applied, the liquid crystal molecules near the alignment films are aligned in a horizontal direction, but the liquid crystal molecules in the middle parts of cells erect themselves halfway. The birefringent property of the liquid crystal is lost to some extent. This causes transmittance to deteriorate and brings about halftone

(gray) display. However, this effect occurs only to light incident perpendicularly on the liquid-crystal panel. Obliquely incident light is seen differently, that is, light is seen differently depending on whether it is seen from the left or right side of the drawing (panel). As illustrated, the liquid crystal molecules are aligned mutually parallel relative to light propagating from right below to left above. The liquid crystal hardly exerts a birefringent effect. Therefore, when the panel is seen from left, it is seen black. By contrast, the liquid crystal molecules are aligned vertically relative to light propagating from below on the right to above on the left. The liquid crystal exerts a great birefringent effect relative to incident light, and the incident light is twisted. This results in nearly white display. Thus, the most critical drawback of the TN LCD is that the display state varies depending on the viewing angle.

It is known that viewing angle performance of a liquid crystal display device (LCD) in the TN mode can be improved by setting the orientation directions of the liquid crystal molecules inside pixels to a plurality of mutually different directions. Generally, the orientation direction of the liquid crystal molecules (pre-tilt angles) that keep contact with a substrate surface in the TN mode are restricted by the direction of a rubbing treatment applied to the alignment film. The rubbing treatment is a process which rubs the surface of the alignment film in one direction by a cloth such as rayon, and the liquid crystal molecules contacting the alignment film are orientated in the rubbing direction. Therefore, viewing angle performance can be improved by making the rubbing direction different inside the pixels.

Figs. 2A to 2C show a method of making the rubbing direction different inside the pixels. As shown in this drawing, an alignment film 101 is formed on a glass substrate

100 (whose electrodes, etc., are omitted from the drawing). This alignment film 101 is then bought into contact with a rotating rubbing roll 102 to execute the rubbing treatment in one direction. Next, a photo-resist is applied to the alignment film 101 and a predetermined pattern is exposed and developed by photolithography. As a result, a patterned layer 103 of the photo-resist is formed as shown in Figs. 2B and 2C. Next, the alignment film 101 is brought into contact with a rubbing roll 201 that is rotating in a direction opposite the direction of the previous rotating rubbing roll 102, so that only the open portions of the pattern are rubbed. In this way, a plurality of regions that are subjected to the rubbing treatment in different directions are formed inside the pixel, and the plural orientation directions of the liquid crystal are formed inside the pixel. Incidentally, the rubbing treatment can be done in arbitrarily different directions when the alignment film 101 is rotated relative to the rubbing roll 102.

As described above, there are some problems related to a division of orientation directions of the liquid crystal molecules for improving the viewing angle performance in the VA LCD.

It is desirable to improve a viewing angle characteristic of a VA liquid crystal display, and to realize a VA liquid crystal display exhibiting a viewing angle characteristic that is as good as or better than that exhibited by an in-plane switching (IPS) mode LCD, while permitting the same contrast and operation speed as the conventional liquid crystal displays.

According the an embodiment of the present invention, a VA mode LCD uses a conventional vertical alignment film, and adopting a negative liquid crystal, and a domain regulating means for regulating the orientation of a liquid crystal. Liquid crystal molecules are

aligned obliquely when a voltage is applied, so that the orientation will include a plurality of directions within each pixel. The domain regulating means is provided on at least one of the substrates. Further, at least one of domain regulating means has inclined surfaces (slopes). The inclined surfaces include surfaces which are almost vertical to the substrates. Rubbing need not be performed on the vertical alignment film.

In the VA LCD device, when no voltage is applied, in almost all regions of the liquid crystal other than the protrusions, liquid crystal molecules are aligned nearly vertically to the surfaces of the substrates. The liquid crystal molecules near the inclined surfaces also orientate vertically to the inclined surfaces. When a voltage is applied, the liquid crystal molecules tilt according to electric field strength. Since the electric fields are vertical to the substrates, when a direction of tilt is not defined by carrying out rubbing, the azimuth in which the liquid crystal molecules tilt includes all directions of 360°. If there are pre-tilted liquid crystal molecules, surrounding liquid crystal molecules are tilted in the directions of the pre-tilted liquid crystal molecules. Even when rubbing is not carried out, the directions in which the liquid crystal molecules lying in gaps between the protrusions can be restricted to the azimuths of the liquid crystal molecules in contact with the surfaces of the protrusions. When voltage is increased, the negative liquid crystal molecules are tilted in directions vertical to the electric fields.

Recently, a liquid crystal display device which drives a liquid crystal by an auxiliary electrode, which is electrically insulated from a pixel electrode, without aligning the liquid crystal has been suggested. Such a related art liquid crystal display device will be described with reference to Fig. 3.

As shown in Fig. 3, the related art liquid crystal display device includes a first substrate, a second substrate, a plurality of data lines and gate lines, a thin film transistor, a passivation film 37, a pixel electrode 13, and an auxiliary electrode 21. The data lines and gate lines are formed on the first substrate lengthwise and crosswise to divide the first substrate into a plurality of pixel regions. The thin film transistor is formed in each pixel region on the first substrate and includes a gate electrode, a gate insulating film, a semiconductor layer, an ohmic contact layer, and source/drain electrodes. The passivation film 37 is formed on the first substrate. The pixel electrode 13 is formed on the passivation film 37 to be connected with the drain electrode. The auxiliary electrode 21 is formed on the gate insulating film to partially overlap the pixel electrode 13.

The related art liquid crystal display device further includes a light-shielding layer 25, a color filter layer 23 formed on the light-shielding layer 25, a common electrode formed on the color filter layer 23, and a liquid crystal layer formed between the first substrate and the second substrate. The light-shielding layer 25 is formed on the second substrate to shield light leaked from the gate lines, the data lines, and the thin film transistor.

The auxiliary electrode 21 formed around the pixel electrode 13 and an open region 27 of a common electrode 17 distort electric field applied to the liquid crystal layer so that liquid crystal molecules are variously driven within a unit pixel. This is intended that a dielectric energy by the distorted electric field places a liquid crystal director at a desired position when a voltage is applied to the liquid crystal display device.

However, the liquid crystal display device requires the open region 27 in the common electrode 17 to obtain multi-domain effect. To this end, the process for patterning the common electrode is additionally required.

Furthermore, if the open region 27 is not formed or has a small width, distortion range of the electric field required to divide the domain is weak. Accordingly, there is a problem that, the time required for the liquid crystal director to reache a stable state, relatively increases. Such a domain division by the open region 27 causes unstable textures for each domain, thereby deteriorating picture quality. Also, because high electric field is applied between the pixel electrode 13 and the auxiliary electrode 21, luminance and response speed decrease.

SUMMARY OF THE INVENTION

Accordingly, the present invention is directed to a multi-domain liquid crystal display device that substantially obviates one or more of the problems due to limitations and disadvantages of the related art.

An object of the present invention is to provide provide a multi-domain liquid crystal display device in which a common auxiliary electrode is formed around and in a pixel region on a layer equal to a gate line, and electric field induction windows and dielectric structures are formed in the pixel region, so that stable texture and multi-domain effect can be obtained.

A multi-domain liquid crystal display device of the present invention is an improved invention of the Korean Patent Application No. 1999-07633 filed by the same applicant of this invention, in which a common auxiliary electrode is formed around a pixel region on a layer equal to a gate line, and electric field induction windows and dielectric structures are formed in the pixel region.

Additional features and advantages of the invention will be set forth in the description which follows, and in part will be apparent from the description, or may be learned by practice of the invention. The objectives and other advantages of the invention will be realized and attained by the structure particularly pointed out in the written description and claims hereof as well as the appended drawings.

To achieve these and other advantages and in accordance with the purpose of the present invention, as embodied and broadly described, a multi-domain liquid crystal display device according to the present invention includes: first and second substrates opposing each other; a liquid crystal layer formed between the first substrate and the second substrate; a plurality of gate lines and data lines formed on the first substrate lengthwise and crosswise to define pixel regions; a pixel electrode formed in the pixel regions; at least one or more electric field induction windows independently formed in the pixel electrode; a common auxiliary electrode formed on a layer equal to the gate lines to surround the pixel regions; a common electrode formed on the second substrate; at least one or more dielectric structures independently formed on the common electrode to distort electric field applied to the liquid crystal layer; and an alignment film formed on at least one of the first and second substrates. The multi-domain liquid crystal display device further includes a common auxiliary electrode formed in a region where the electric field induction windows are formed, and the dielectric structures are formed to maintain a cell gap of the liquid crystal display device.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

BRIEF DESCRIPTION OF THE DRAWING

The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and together with the description serve to explain the principles of the invention.

In the drawings:

Figs. 1A to 1C are diagram for explaining problem of TN TFT LCD;

Figs. 2A to 2C show a method of making the rubbing direction different inside the pixels;

Fig. 3 is a sectional view showing a related art liquid crystal display device;

Figs. 4A and 4B are plane views showing a multi-domain liquid crystal display device according to the first embodiment of the present invention;

Fig. 5 is a plane view showing a multi-domain liquid crystal display device according to the present invention.

Figs. 6A to 6F are sectional views showing a multi-domain liquid crystal display device, taken along lines I-I' of Fig. 4A;

Figs. 7A and 7B are plane views showing a multi-domain liquid crystal display device according to the second embodiment of the present invention;

Figs. 8A to 8F are sectional views showing a multi-domain liquid crystal display device, taken along lines II-II' of Fig. 7A;

Figs. 9A and 9B are plane views showing a multi-domain liquid crystal display device according to the third embodiment of the present invention;

Figs. 10A to 10F are sectional views showing a multi-domain liquid crystal display device, taken along line III-III' of Fig. 9A;

Figs. 11A and 11B are plane views showing a multi-domain liquid crystal display device according to the fourth embodiment of the present invention;

Figs. 12A to 12F are sectional views showing a multi-domain liquid crystal display device, taken along line IV-IV' of Fig. 11A; and

Figs. 13A to 13B show textures when driving a related art liquid crystal display device and a multi-domain liquid crystal display device according to the present invention.

Fig. 14 is plane view showing a multi-domain liquid crystal display device using U-type thin film transistor according to another embodiment to the present invention;

Figs. 15A to 15B are sectional views showing a multi-domain liquid crystal display device, taken along lines IV-IV'and V-V'of Fig. 14.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Reference will now be made in detail to the preferred embodiment of the present invention, example of which is illustrated in the accompanying drawings.

A multi-domain liquid crystal display device of the present invention will be described with reference to the accompanying drawings.

As shown in Figs. 4-15, the multi-domain liquid crystal display device includes a first substrate 31, a second substrate 33, a plurality of data lines 3 and gate lines 1, a common auxiliary electrode 15, a thin film transistor, a passivation film 37, and a pixel electrode 13.

The data lines 3 and gate lines 1 are formed on the first substrate 31 lengthwise

and crosswise to divide the first substrate into a plurality of pixel regions. The common

auxiliary electrode 15 is formed on the same layer as the gate lines 1 to distort electric field.

The thin film transistor is formed in each pixel region on the first substrate and includes a

gate electrode 11, a gate insulating film 35, a semiconductor layer 5, an ohmic contact layer 6,

and source/drain electrodes 7 and 9. The passivation film 37 is formed on an entire surface of

the first substrate 31. The pixel electrode 13 is formed on the passivation film 37 to be

connected with the drain electrode 9.

At least one or more electric field induction windows 51 are independently

formed in the pixel electrode 13 to compensate electric field formed by the common auxiliary

electrode 15. Also, the pixel electrode 13 partially overlaps the common auxiliary electrode

15 and acts to remove disclination caused by uneven electric field applied from the common

auxiliary electrode 15 and the pixel electrode 13 (Figs. 4, 5, 6, 9 and 10).

The multi-domain liquid crystal display device further includes a light-

shielding layer 25, a color filter layer 23 formed on the light-shielding layer 25, a common

electrode 17 formed on the color filter layer 25, and a liquid crystal layer formed between the

first substrate and the second substrate. The light-shielding layer 25 is formed on the second

substrate 33 to shield light leaked from the gate lines 1, the data lines 3 and the thin film

transistor.

One or more dielectric structures 53 are independently formed on the common

electrode 17. The dielectric structures 53 variously distort the electric field applied to the

liquid crystal layer to achieve display stability of the liquid crystal display device and multi-

domain effect. If the dielectric structures 53 are formed high to maintain a cell gap, the dielectric structures 53 act as spacers of the liquid crystal display device.

The dielectric structures 53 is a single point that stabilizes a screen in the pixel regions and displays uniform picture. That is to say, more stable screen display can be obtained by using the dielectric structures 53.

As shown in Figs. 5, 6, 8, 10 and 12, to fabricate the aforementioned multi-domain liquid crystal display device, the thin film transistor comprising the gate electrode 11, the gate insulating film 35, the semiconductor layer 5, the ohmic contact layer and the source/drain electrodes 7 and 9 is formed in each pixel region of the first substrate 31. At this time, the plurality of gate lines 1 and data lines 3 are formed to divide the first substrate 31 into a plurality of pixel regions.

The gate electrode 11 and the gate lines 1 are formed in such a manner that metals such as Al, Mo, Cr, Ta, or Al alloy, or a double layer formed of two of these metals, are layered by sputtering and patterned. At the same time, the common auxiliary electrode 15 is formed to surround the pixel region. The gate insulating film 35 is formed in such a manner that SiN_x or SiO_x is deposited on the common auxiliary electrode by plasma enhancement chemical vapor deposition (PECVD). Subsequently, the semiconductor layer 5 and the ohmic contact layer are formed in such a manner that a-Si and n^+ a-Si are deposited by PECVD and patterned. Alternatively, the gate insulating film 35 is formed in such a manner that SiN_x or SiO_x, a-Si and n^+ a-Si are successively deposited. The semiconductor layer 5 and the ohmic contact layer 6 are formed in such a manner that a-Si and n^+ a-Si are patterned. To improve aperture ratio, the gate insulating film 35 may be formed of BCB (BenzoCycloButene), acrylic resin, or polyimide compound.

Metals such as Al, Mo, Cr, Ta or Al alloy, or double layers of two of these metals, are layered by sputtering and patterned so that the data lines 3 and the source/drain electrodes 7 and 9 are formed. At this time, a storage electrode is formed to overlap the gate lines 1 and/or the common auxiliary electrode 15. The storage electrode acts as a storage capacitor together with the gate lines 1 and/or the common auxiliary electrode 15.

Subsequently, the passivation film 37 is formed of a material such as BCB, acrylic resin, polyimide compound, SiN_X or SiO_X on the first substrate 31. A metal such as indium tin oxide (ITO) is deposited by sputtering and patterned to form the pixel electrode 13.

At this time, the pixel electrode 13 is connected with the drain electrode 9 and the storage electrode through a contact hole and patterned in various forms to form electric field induction windows therein.

When the common auxiliary electrode 15 is formed of the same material as the gate lines 1, it is formed on the same layer as the gate lines 1 and electrically connected with the common electrode 17 using one mask. An additional mask may be used to form other metal or different double layers. Alternatively, the common auxiliary electrode 15 may be formed on a layer equal to the pixel electrode 13.

In the embodiments according to the liquid crystal display device of the present invention, L-shaped thin film transistors having high aperture ratio are shown. The L-shaped TFT has an improved aperture ratio as compared with the related art due to its L-shape, and can reduce parasitic capacitance generated between the gate line and the drain electrode 9.

Also the thin film transistor may be formed in a U shape. Namely, the U

shaped thin film transistor 7A having the source electrode which surrounds the drain

electrode may be formed in a portion where the gate lines cross the data lines, as shown in

Figs. 14.

As shown in Fig. 14, the dielectric structure 53 is patterned in a zig-zag shape.

A plurality of electric field induction windows 51 are formed within the pixel region, and a

projection is formed in the dielectric structure 53 at a boundary portion, bending portion or

crossing portion of the pixel region.

Meanwhile, Fig. 15A is a sectional view taken along line IV-IV' of Fig. 14,

and Fig. 15B is a sectional view taken along line V-V'. A metal such as Al, Mo, Cr, Ta, or Al

alloy is formed on the first substrate 31 by sputtering method. The metal is then patterned to

form the gate lines 1, the gate electrodes 11, and the first gate electrode 43 of the storage

capacitor. A gate insulating film 35 of silicon nitride or silicon oxide is formed on the entire

surface of the substrate including the gate electrode 11 by plasma CVD.

At this time, to improve aperture ratio, the gate insulating film may be formed

of BCB, acrylic resin or polyimide compound.

Afterwards, an amorphous silicon layer and n+amorphous silicon layer are

stacked on the gate insulating film 35 and then patterned to form a semiconductor layer 5 and

an ohmic contact layer 6. Alternatively, the gate insulating film of silicon nitride or silicon

oxide, the amorphous silicon layer, and n+amorphous silicon layer may sequentially be

deposited, and the amorphous silicon layer and the n+amorphous silicon layer may be

patterned to form the semiconductor layer 5 and the ohmic contact layer 6.

A metal such as Al, Mo, Cr, Ta, or Al alloy is formed by sputtering method and then patterned to form the data lines in a direction crossing the gate lines, the drain electrode 9 of the thin film transistor, the source electrode 7 surrounding the drain electrode 9, and the second electrode 43A of the storage capacitor.

Subsequently, the passivation film 37 of BCB, acrylic resin, polyimide compound, silicon nitride, or silicon oxide is formed on the entire surface including the source/drain electrodes 7 and 9 and the second electrode 43A of the storage capacitor. A transparent conductive material such ITO is formed and then patterned to form the pixel electrode 13 having the electric field induction window 51 of a plurality of hole or silt shapes within each domain.

As described above, problems related to flicker and image quality can be solved by forming the thin film transistor in a U shape.

The light-shielding layer 25 is formed on the second substrate 33, and the color filter layer 23 is formed to repeat R (red), G (green) and B (blue) elements for each pixel. The common electrode 17 is formed of a transparent electrode such as ITO on the color filter layer 23, in the same manner as the pixel electrode 13. A photoresist material is deposited on the common electrode 17 and patterned by photolithography to form dielectric structures 53. Additionally, the common electrode 17 may be patterned in various forms to form electric field induction windows 51 such as hole or slit.

Subsequently, liquid crystal is injected between the first substrate 31 and the second substrate 33 so that a multi-domain liquid crystal display device is completed. The liquid crystal has a positive dielectric anisotropy or a negative dielectric anisotropy. The liquid crystal may have a chiral dopant.

The liquid crystal is injected by dispenser method. Namely, a seal pattern for bonding two substrates is formed on the first substrate 31, and the liquid crystal is injected into the seal pattern by the dispenser method.

After a spacer is distributed on the second substrate 33 to uniformly maintain the cell gap of the liquid crystal, the first substrate 31 in which the seal pattern is formed and the second substrate 33 are bonded to each other. The seal pattern is then hardened by giving UV only or UV and heat.

Meanwhile, to form the liquid crystal layer, in addition to a method for dropping the liquid crystal in a decompression state, after making the inside of the cell in vacuum state, using the resultant pressure difference (capillary tube phenomenon) the liquid crystal may be entered into the cell. Alternatively, a generally known method for injecting a liquid crystal may be applied. For reference, when the dispenser method is applied to a large sized substrate, it is possible to reduce liquid crystal formation time. When liquid crystal having a negative dielectric anisotropy is used, it is possible to improve injection time of the liquid crystal because viscosity of the liquid crystal is high. Also, a columned spacer may be used as the spacer, and a UV hardening type seal material, or a seal material that can be hardened at a room temperature may be used as a material of the seal pattern.

The dielectric structures 53 are independently formed and distort electric field applied to the liquid crystal layer. Preferably, the dielectric structures 53 have dielectric constants equal to or smaller than the liquid crystal layer, and more preferably 3 or below. A material such as photoacrylate or BCB may be used for the dielectric structures.

To apply a voltage V_{com} to the common auxiliary electrode 15, an Ag-Dotting portion is formed in each corner of a driving region of the liquid crystal display device on the

first substrate 31. The electric field is applied to the second substrate 33 to drive the liquid

crystal by the potential difference between upper and lower substrates. The Ag-Dotting

portion of each corner is connected with the common auxiliary electrode 15. Thus, the voltage

V_{com} is applied to the common auxiliary electrode 15. This process is performed when

forming the common auxiliary electrode 15.

A phase difference film 29 is formed on at least one of the first substrate 31

and the second substrate 33.

The phase difference film 29 is a negative uniaxial film having one axis and

acts to compensate a viewing angle of a user.

Therefore, a region having no gray inversion is expanded, contrast ratio in

incline direction increases, and a multi-domain is formed by one pixel. Thus, a viewing angle

in left and right direction can effectively be compensated.

In addition to the negative uniaxial film, a negative biaxial film having two

axes may be formed as the phase difference film. The negative biaxial film can obtain

viewing angle characteristic wider than the negative uniaxial film.

After attaching the phase difference film, a polarizer (not shown) is attached

on both substrates. The polarizer may be formed in an integral form with the phase difference

film.

In the multi-domain liquid crystal display device shown in Figs. 4A and 4B, at

least one or more electric field induction windows 51 are formed in the pixel electrode 13.

The common auxiliary electrode 15 is formed around the pixel regions, and dielectric

structures 53 are formed in the pixel regions. In this structure, the pixel electrode 13 does not

overlap the common auxiliary electrode 15 while the light-shielding layer 25 overlaps the pixel electrode to prevent light from being leaked out.

In Figs. 6A and 6B, the dielectric structures 53 have low projection shapes. In Figs. 6C and 6D, the dielectric structures 53 extend to the second substrate to maintain a cell gap of the liquid crystal display device. In Figs. 6A and 6C, the passivation film 37 is formed of a material such as SiN_X or SiO_X. In Figs. 6B and 6D, the passivation film 37 is formed of BCB, acrylic resin or polyimide compound. In Figs. 6E and 6F, the dielectric structures 53 have low projection shapes on the pixel electrode 13.

In the multi-domain liquid crystal display device shown in Figs. 7A and 7B, at least one or more electric field induction windows 51 are formed in the pixel electrode 13, the common auxiliary electrode 15 is formed around the pixel regions, and dielectric structures 53 are formed in the pixel regions. In this structure, the pixel electrode 13 overlaps the common auxiliary electrode 15 to form a storage capacitor. The light-shielding layer 25 also overlaps the common auxiliary electrode 15 to improve aperture ratio.

In Figs. 8A and 8B, the dielectric structures have low projection shapes. In Figs. 8C and 8D, the dielectric structures extend to the second substrate to maintain a cell gap of the liquid crystal display device. In Figs. 8A and 8C, the passivation film 37 is formed of a material such as SiN_X or SiO_X. In Figs. 8B and 8D, the passivation film 37 is formed of BCB, acrylic resin or polyimide compound. In Figs. 8E and 8F, the dielectric structures 53 have low projection shapes on the pixel electrode 13.

In the multi-domain liquid crystal display device shown in Figs. 9A and 9B, at least one or more electric field induction windows 51 are formed in the pixel electrode 13. The common auxiliary electrode 15 is formed around the pixel regions and in a region where

the electric field induction windows are formed, and the dielectric structures 53 are formed in the pixel regions. In this structure, the pixel electrode 13 does not overlap the common auxiliary electrode 15 while the light-shielding layer 25 overlaps the pixel electrode 13 to prevent light from being leaked out.

In Figs. 10A and 10B, the dielectric structures have low projection shapes. In Figs. 10C and 10D, the dielectric structures 53 extend to the second substrate to maintain a cell gap of the liquid crystal display device. In Figs. 10A and 10C, the passivation film 37 is formed of a material such as SiN_X or SiO_X. In Figs. 10B and 10D, the passivation film 37 is formed of BCB, acrylic resin or polyimide compound. In Figs. 10E and 10F, the dielectric structures 53 have low projection shapes on the pixel electrode 13.

In the multi-domain liquid crystal display device shown in Figs. 11A and 11b, at least one or more electric field induction windows 51 are formed in the pixel electrode 13, the common auxiliary electrode 15 is formed around the pixel regions and in a region where the electric field induction windows are formed, and the dielectric structures 53 are formed in the pixel regions. In this structure, the pixel electrode 13 overlaps the common auxiliary electrode 15 to form a storage capacitor. The light-shielding layer 25 also overlaps the common auxiliary electrode 15 to improve aperture ratio.

In Figs. 12A and 12B, the dielectric structure 53s have low projection shapes. In Figs. 12C and 12D, the dielectric structures extend to the second substrate to maintain a cell gap of the liquid crystal display device. In Figs. 12A and 12C, the passivation film 37 is formed of a material such as SiN_X or SiO_X. In Figs. 12B and 12D, the passivation film 37 is formed of BCB, acrylic resin or polyimide compound. In Figs. 12E and 12F, the dielectric structures 53 have low projection shapes on the pixel electrode 13.

Figs. 13A to 13B show textures when driving a multi-domain liquid crystal

display device according to the present invention and a related art liquid crystal display

device.

Referring to Fig. 13A, the dielectric structure in the pixel region controls the

electric field. Therefore, it is noted that uniform texture is formed for each domain. However,

in Fig. 13B, it is noted that uneven texture is formed for each domain, thereby causing poor

picture display.

Additionally, in the multi-domain liquid crystal display device of the present

invention, an alignment film (not shown) is formed on the first substrate and/or the second

substrate. The alignment film is formed of a photo reactive material such as

PVCN (Polyvinylcinnamate), PSCN (Polysiloxanecinnamate), or

CelCN (Cellulosecinnamate). The other materials suitable for photo-alignment may be used

as the alignment film.

Light is radiated to the photo-alignment film at least one time to determine a

pretilt angle and alignment direction or pretilt direction of the director of the liquid crystal

molecule simultaneously, thereby obtaining stable alignment of the liquid crystal. The

ultraviolet light is suitable for the photo-alignment. Non-polarized light, unpolarited light

linear-polarized light or partially polarized light may be used for the photo-alignment.

Photo-alignment or rubbing is applicable to one of the first substrate and the

second substrate or both substrates. Different alignment methods are applicable to both

substrates. Optimally, alignment process may be skipped, even after forming the alignment

film.

Furthermore, the aforementioned alignment is performed to form the multi-domain liquid crystal display device divided into at least two regions. Thus, the liquid crystal molecule of the liquid crystal layer may be aligned differently on each region. In other words, each pixel is divided into four regions in + shape or X shape, or each pixel is divided in horizontal, vertical, or diagonal direction. Alignment process or alignment direction is varied depending on each region and each substrate, so that multi-domain effect can be realized. At least one region of the divided regions may be an "unaligned" region or all the divided regions may be unaligned.

As aforementioned, the multi-domain liquid crystal display device has the following advantages.

The common auxiliary electrode is formed on the same layer as the gate lines around and/or in the pixel region. The electric field induction windows and the dielectric structures, as well as the common auxiliary electrode, are formed within the pixel electrode so that the electric field distortion can be induced. Thus, alignment direction is easily controlled within the domain, and stable texture in picture display is obtained. Thus, the viewing angle and the multi-domain effect are improved. In addition, because the common auxiliary electrode is formed on the same layer as the gate lines, electrical shorting between the pixel electrode and the common auxiliary electrode is avoided and yield can be improved.

It will be apparent to those skilled in the art that various modifications and variation can be made in the present invention without departing from the spirit or scope of the invention. Thus, it is intended that the present invention cover the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.